irig Institut de Recherche Interdisciplinaire de Grenoble

Pheliqs Quantum Physics & Engineering

Master Project

Ballistic semiconductor-superconductor hybrid devices

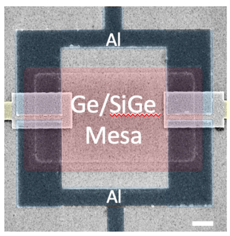
In a superconductor, electrons form so-called Cooper pairs that can carry an electrical current without dissipation. These pairing correlations can also occur in a normal-type conducting material when it is intimately connected to a superconductor. Such a phenomenon, known as the superconducting proximity effect, can make a normal conductor become superconducting. The induced superconductivity will be tunable if one can change. If a semiconductor is used as normal-type element, one can envision tuning the induced superconductivity by means of a gate voltage acting on the electron density in the semiconductor. Even more interesting is the case of a hybrid semiconductor-superconductor device involving a low-dimensional (1D or 2D) semiconductor nanostructure where carriers can ballistically travel all across. The expected resulting physics is very reach and proper tuning of the electronic states in the semiconductor nanostructures can lead to exotic phenomena including topological states of matter. Despite a huge number of theoretical proposals, the realization of these types of hybrid devices has been challenging due to the difficulty to find a combination of materials offering at the same time high-mobility and robust superconducting proximity effect. Recently, the emergence of high-mobility Ge/SiGe heterostructures is opening a new promising route (see Refs [1-4]).

The master student will join a small experimental team already working on the realization of hybrid devices based on Ge/SiGe heterostructures coming from a collaboration with QuTech (Delft). The goal of the project will be to perform low-temperature magneto-transport measurements to study the strength of the superconducting proximity effect and its dependence on applied magnetic fields. The devices are fabricated by a PhD student and a postdoctoral research at the PTA cleanroom. The results of this master project will be used to design more complex devices for a variety of original experiments to be pursued in a following PhD project.

The candidate should show a strong interest in experimental research and have a solid background in solid-state physics and quantum mechanics.

[1] R Mizokuchi et al., Nano Letters 18 (8), 4861 (2018) ; [2] F Vigneau et al., Nano Letters 19 (2), 1023 (2019) ; [3] NW Hendrickx et al.,Nature Commun. 9 (1), 1 (2019) ; [4] G Scappucci et al., arXiv:2004.08133.

Example of hybrid SQUID device fabricated by our team from a Ge/SiGe heterostructure (Ref. 2).



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